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Improved Equity, Diversity, and Inclusion to Sustain an Effective Applied Mathematics Workforce

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It is well known that the demographics of researchers in the Science, Technology, Engineering, and Mathematics (STEM) fields tend to be overwhelmingly white and male, with women and minorities sometimes severely under-represented. While the percentage of women in the total number of students in Bachelor's programs in mathematics and statistics has hovered around 45% in the past two decades, the percentage of women in undergraduate engineering and computer sciences curricula is closer to 20% [NSF, 2017]. Minority students are similarly underrepresented in STEM curricula and the numbers become even more scant when considering those enrolled in graduate degree programs [NSF, 2017]. Of the few women and minorities who enter research careers in the STEM fields, many leave the field over time for a variety of reasons including implicit bias, sometimes overt discrimination, or personal choice, a problem often collectively referred to as the leaky pipeline. As such, women and minorities are under-represented in STEM research fields [Nelson, 2010], and this underrepresentation increases as we look at more senior leadership positions within STEM-focused organizations.

The impact of this lack of diversity on the applied mathematics research community is manifold, with an overall effect of tremendous missed potential and expertise, as well as less innovation in the research conducted. Both of these impacts are further detailed below. The lost potential and expertise comes first of all from the many women and minorities who do not develop an interest in STEM fields, due to for example societal gender roles, or the lack of role models. Second, many students who do pursue a degree in STEM fields feel discouraged from pursuing graduate school or long-term research careers due to many factors including bias [Reuben, 2014], inhospitable culture [Williams, 2016; Seron, 2016], and scarcity of mentorship. The leaky pipeline syndrome presents a tremendous loss of talent and very specialized expertise given the significant investments by DOE in graduate students and early career researchers.

While less often acknowledged, the reduction of innovativeness in applied mathematics research projects is very real and may be one of the biggest hidden costs of a lack of diversity. Numerous studies have shown that diverse teams are more adept at tackling challenging problems and they develop more creative solutions [Hewlett, 2013; Hong, 2004; Nielsen, 2017; Phillips, 2014; Rock, 2016, Woolley, 2011]. A diverse workforce is therefore essential to adequately meeting emerging and future research needs. Note that for optimal team performance and the best research innovation, the diversity needs to be multidimensional. It is not sufficient to have a diversity of disciplines and educational institutions. Gender, ethnicity, race, sexual orientation, and the many other dimensions are necessary ingredients in diversity. Also, this diversity benefits everyone, not just women and minorities: research has demonstrated that all members of diverse teams, including those in dominant groups, better challenge assumptions and focus more strongly on facts.

Working in diverse teams does require a level of cross-cultural awareness on behalf of the team members in order to have an inclusive atmosphere where everyone feels empowered to put in their best thinking and to take risks. Diverse teams often struggle in the short term, but produce

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stronger results in the long term. As such, D&I awareness, implementation, and practice are critical skills (not just ideals) that need to be developed in order to meet emerging needs. However, given the many long-term research directions that are part of the DOE applied math portfolio, the initial investments needed to make team diversity flourish are very likely to pay large dividends that will continue to increase with time.

While addressing the lack of diversity in STEM fields has been perceived as a daunting challenge, there are many things DOE ASCR can do. A strong contribution would be to help characterize the scope of the problem and to raise awareness of its relevance, for example through the sponsoring of workshops and minisymposia at major STEM conferences on the topic. Further, DOE could require that all institutions that receive DOE grant money track and publicly disclose the demographics of their workforce, broken down across job levels and across Principal Investigators (PIs) who lead internally and externally funded projects. Next, DOE could require that research proposals address team diversity in their management plans, and that they include an outreach plan that receives a meaningful weight in the proposal review criteria. The makeup of proposal review panels should be diverse, with panelists who are aware of unconscious bias and other issues impacting grant awards to women and minorities. Similarly, DOE programs such as the Workforce Development for Teachers and Scientists and the Computational Science Graduate Fellowship could be enhanced [WDTS, 2017], to promote and support a more diverse participant pool for example through outreach to currently underrepresented communities, or an analysis of the application and selection process.

Besides these programmatic aspects, it is very important for DOE to promote the development of stronger Equity, Diversity and Inclusion (EDI) skills for both future and existing applied mathematics researchers. This could be achieved through collaborations with academia, or also through a grant program, similar to the NSF ADVANCE program [NSF, 2017b], to provide funding and logistical support for organizational culture change programs. As organizational culture change takes time, it is crucial that training programs emphasize deep EDI capacity building (rather than merely standards-based compliance training), and that ongoing support is provided for the people engaged in implementing the programs. All people in leadership positions such as management and research project PIs should be involved in these EDI skills development programs.

It is only when women and minorities feel a stronger sense of belonging in STEM, receive the support they need to build out their research careers, and feel valued in their professions, that more women and minorities will choose to enter and remain in STEM careers [Misra, 2017; Williams, 2016]. This will in turn result in a stronger representation of women and minorities in prominent positions, where they will be seen as mentors and role models and inspire young students to pursue careers in STEM.

In conclusion, while the current lack of diversity in the STEM workforce is a big concern, it also represents a huge source of untapped and unrealized potential. Organizations that are able to harness the power of a diverse workforce will be well positioned to tackle emerging and future research challenges. As such, improving the EDI aspects of applied mathematics research projects and teams may be one of the most powerful levers to not just sustaining, but also growing the applied mathematics workforce and products.

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